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October 6, 2016

VIA ECFS

Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, SW
Washington, DC 20554

Re: *Business Data Services in an Internet Protocol Environment*, WC Docket No. 16-143; *Investigation of Certain Price Cap Local Exchange Carrier Business Data Services Tariff Pricing Plans*, WC Docket No. 15-247; *Special Access for Price Cap Local Exchange Carriers; AT&T Corp. Petition for Rulemaking to Reform Regulation of Incumbent Local Exchange Carrier Rates for Interstate Special Access Services*, WC Docket No. 05-25, RM-10593

Dear Ms. Dortch:

CenturyLink hereby submits a Supplemental Declaration by Drs. Mark Schankerman and Pierre Régibeau. The Supplemental Declaration further demonstrates the flaws inherent in Sprint's latest arguments for extreme reductions in the tariffed rates for business data services ("BDS"). Specifically, David E.M. Sappington and Chris Frentrup submitted a declaration on Sprint's behalf that effectively disavows Sprint's previous support for the use of EU KLEMS data for purposes of computing an appropriate catch-up rate cut and annual X-factor.[1] Instead, they argue, the Commission should rely on Connect America Cost Model ("CACM") data to justify drastic rate cuts.[2] In response, AT&T recently submitted a supplemental declaration prepared by Christensen Associates demonstrating various flaws in the Frentrup-Sappington analysis.[3] The enclosed Supplemental Schankerman/Régibeau Declaration provides additional refutation of Sprint's latest proposal.

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[1] *See generally* Declaration of Chris Frentrup and David E.M. Sappington, attached to Letter from Jennifer Bagg, Counsel to Sprint Corp., to Marlene H. Dortch, Secretary, FCC, WC Docket Nos. 16-143 *et al.* (filed Aug. 31, 2016).

[2] *See id.*

[3] *See* Christensen Associates, Reply Comment of Mark E. Meitzen & Philip E. Schoech, WC Docket Nos. 16-143 *et al.* (filed Sept. 22, 2016).

As the Supplemental Schankerman/Régibeau Declaration demonstrates, the Bureau of Labor Statistics ("BLS") KLEMS method is the best approach for establishing the X-factor. As a result, there is no legitimate justification in the record for anything other than, at most, a modest reset. The Supplemental Schankerman/Régibeau Declaration also makes the following key points:

- Contrary to some claims, the inclusion of broadcasting in the official BLS indexes of input price and total factor productivity ("TFP") growth, which are based on the KLEMS data and state-of-the-art methodology, does not result in any understatement of the index for DS1/DS3 services. In fact, there is strong evidence that the presence of broadcasting in this index tends to *overstate* the TFP growth for wired telecommunications, and especially DS1/DS3 services, over the past decade.

- Even if the CACM-based price index that Frentrup and Sappington now recommend were a better measure of the prices faced by BDS service suppliers than the BLS KLEMS price index (which is doubtful in any event), the input price index cannot be modified without also modifying the measure of TFP in order to preserve consistency between the two measures. Properly modifying TFP to account for the new input price index would lead to the same X-factor – and also the same initial price reduction – that results from use of KLEMS-based TFP measures together with the corresponding KLEMS factor price index. The Frentrup-Sappington analysis adjusts one part of the analysis (the input price index) to obtain a higher X-factor but ignores the logical obligation to also adjust the other component, the TFP index.

- The only reason for departing from the KLEMS-based input price index that corresponds to productivity based on gross output is the claim that a CACM-based index might offer a closer approximation to the cost conditions at the level of individual providers of BDS services. However, it makes little sense to try to account for an input mix on the grounds that it might be a closer approximation of the manner in which producers actually combine factors of production without also considering *other* important aspects of BDS service, such as economies of scale and the erosion of the demand for the TDM-based offerings under consideration. In particular, there is no basis for disregarding the potential increase in costs over time attributable to reduction in the demand for BDS services offered by ILECs. This point becomes even more important if one moves away from sectoral input price indices and tries to derive measures of costs that are supposed to better capture the actual cost conditions faced by BDS suppliers. Frentrup and Sappington completely ignore this consideration, as they ignore the underlying linkage between the input price index and the construction of the corresponding TFP index.

- As Christensen Associates has noted, even if one ignored the problems detailed above, the nature of CACM-based data, and the various *ad hoc* adjustments that Frentrup and Sappington have had to make to the data, render their results little more than guesswork.

For all of these reasons, the recent Frentrup-Sappington declaration is no more reliable than the initial – and now jettisoned – report that Sprint previously submitted, also co-authored by Dr. Sappington (then joined by William Zarakas). As a result, the Commission has no record support for adopting Sprint's extreme proposals.

Please contact the undersigned with any questions.

Sincerely,

/s/ Russell P. Hanser

_____

Russell P. Hanser
Brian W. Murray
WILKINSON BARKER KNAUER LLP

Enclosure

Supplemental Declaration:

Comments on the Frentrup-Sappington Report

Prepared for

Prepared by

Professor Mark Schankerman
and Dr Pierre Régibeau

Date: 06/10/2016

CRA Charles River Associates

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1. INTRODUCTION

In his previous declaration, David Sappington (and William Zarakas) concluded that both the initial reset of BDS service prices and the X-factor to be used for ongoing price regulation should be quite substantial.[1] This analysis relied on EU-KLEMS data which the authors claimed to be more appropriate to the task at hand because it supposedly allowed them to isolate the telecommunications sector, while the US-KLEMS data combines the telecommunications and broadcasting sectors (this claim was later proved to be false, as both the US and EU KLEMS-based productivity data include both sectors).

As explained in our previous report, as well as in the August 9th report by Christensen Associates,[2] the Sappington-Zarakas analysis suffered from two major logical errors. The first mistake was that the authors did not adjust their computations to account for the fact that EU-KLEMS TFP estimates are based on value-added. To translate these in terms of total output, one needs to divide those estimates by the ratio between gross output and value added. Failure to do so erroneously inflates TFP estimates by a factor of about 1.8. The second logical mistake was to use the EU-KLEMS input price index even though this index does not include the cost of labor and capital, which make up most of value added. As we will explain in Section 2, TFP analysis only makes sense if there is a strict correspondence between the factors that make up the expenditures from which the TFP analysis starts and the factors included in the input price index used in the procedure. An analysis that starts from value-added numbers, and then uses an input price index that does not include the prices of its key components, produces meaningless results.

Our own previous report, as well as the initial report of Meitzen and Schoech from Christensen Associates, showed that once one relies on a consistent set of data (the US-KLEMS), the extent of the initial reset of BDS service prices and the X-factor on which future regulation should be based are both much smaller than those suggested by the Sappington-Zarakas analysis. Indeed, our own report suggested that the evidence indicated that the current price would justify a small initial *increase* in order to compensate BDS service suppliers for overly restrictive regulation over the previous decade. There was no credible evidence whatsoever that would support a significant reduction in the initial prices (reset) or a large X-factor going forward (our analysis suggested an X-factor of about 1% per year).

Now Sappington has produced a second declaration with another co-author (Frentrup).[3] This new declaration does not refer to the first one, nor does it take on board any of the other core objections presented in other expert reports. Perhaps most notable is that the fact that, while the Sappington-Zarakas declaration gave no credence to approaches based on the CACM data – opting instead for the EU-KLEMS data – in their new

[1] Declaration of David E. M. Sappington and William P. Zarakas, Exhibit E to the Comments of Sprint Corporation, WC Docket pos. 16-143, *et al.*, filed June 28, 2016 before the Federal Communications Commission, Washington, D.C. 20554

[2] Christensen Associates, Reply Comment of Mark E. Meitzen & Philip E. Schoech, WC Docket Nos. 16-143, 15-247, 05-25, RM-10593 (filed Aug. 9, 2016) (Christensen August 9th Report).

[3] Declaration of Chris Frentrup and David E.M. Sappington, 31 August 2016

declaration, Frentrup and Sappington are now ardent proponents of the CACM as the basis for deriving the input price index to be used in the calculation of X-factor.

Meitzen and Schoech have produced a detailed response to the new Frentrup–Sappington declaration.[4] We agree with the substance of their criticisms of the Frentrup-Sappington analysis. The purpose of this brief declaration is threefold: 1) to register our agreement with the key observations in the Christensen Associates supplemental declaration, 2) to highlight certain fundamental flaws in the new Frentrup-Sappington declaration, and 3) to articulate these flaws in a manner that links back to our own earlier report so that the reader can easily refer to the more detailed analysis contained therein.

We begin by explaining how the calculation of TFP is inextricably linked to a given input price index. This link is just not a mathematical nicety – as Frentrup and Sappington try to portray it – it is an essential part of the logic that produces credible TFP estimates. Without that link, there is no solid economic basis for TFP estimates. This leads us immediately to one of two main flaws in the Frentrup-Sappington report: even if the CACM-based price index that they now recommend were a better measure of the prices faced by BDS service suppliers than the KLEMS price index (and we are not convinced of this, as explained later), one cannot modify the input price index without also modifying the measure of TFP in order to preserve consistency between the two measures. Indeed, we show that properly modifying TFP to account for the new input price index would lead to the *same X-factor* – and hence also the same level of initial price reset – that obtains when using KLEMS-based TFP measures together with the corresponding KLEMS factor price index. The Frentrup-Sappington analysis adjusts one part of the analysis (the input price index) to obtain a higher X-factor but ignores the logical obligation to also adjust the other component, the TFP index.

The second important flaw of the Frentrup-Sappington analysis relates to the CACM-based input price index itself. The only reason for departing from the KLEMS-based input price index that corresponds to productivity based on gross output is the claim that a CACM-based index might offer a closer approximation to the cost conditions at the level of individual providers of BDS services. However, it makes little sense to try to account for an input mix on the grounds that it might be a closer approximation of the manner in which producers actually combine factors of production, and not also consider other important aspects of the technology of BSD service producers, notably economies of scale and the secular erosion of the demand for these TDM-based services. In particular, it is hard to defend disregarding the potential increase in costs over time due to a reduction in the demand for BDS services offered by ILECs. We already highlighted this effect in our previous report.[5] This point becomes even more important if one moves away from sectoral input price indices and tries to derive measures of costs that are supposed to better capture the actual cost conditions fact by BDS suppliers. Frentrup and Sappington completely ignore this consideration, as they ignore the underlying linkage between the input price index and the construction of the corresponding TFP index.

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[4] Christensen Associates, Supplemental Declaration of Mark E. Meitzen & Philip E. Schoech, WC Docket Nos. 16-143, 15-247, 05-25, RM-10593 (filed Sept. 22, 2016) (Christensen September 22nd Declaration).

[5] Mark Schankerman and Pierre Regibeau, "Response to the FCC Further Notice: Regulation of DS1 and DS3 Services," Section 4.3.4, at 32-36 (Aug. 9, 2016).

We then briefly summarize, with limited commentary, other criticisms presented by Mark Meitzen and Philip Schoech of Christensen Associates with which we agree.[6] The bottom line of these objections is that, even if one ignored the gross inconsistency between the TFP estimates and the input price index used by Frentrup and Sappington, and their surprising disregard for the impact of economies of scale and demand erosion for BDS services, the nature of CACM-based data, and the various *ad hoc* adjustments that they have to make to this data to make it resemble a proper input price index, are such that the final result is little more than guesswork.

Overall then, we believe that the new Frentrup-Sappington declaration is no more reliable than the first one by Sappington and Zarakas. We also stress again that the two declarations have almost nothing in common except the fact that they both rely on faulty methodologies and yield considerably higher estimates of the X-factor than conventional methods applied carefully to the available, reliable data. As discussed in Section 6 below, we also believe that the inclusion of broadcasting in the BLS KLEMS-based productivity index does not produce significant bias. In fact, there is strong evidence that the presence of broadcasting in this index tends to overstate the TFP growth for wired telecommunications, and especially DS1/DS3 services, over the past decade.

2. TFP COMPUTATIONS AND INPUT PRICE INDICES ARE INTERTWINED AND CANNOT BE ARTIFICIALLY SEPARATED

The central proposition in the new report by Frentrup and Sappington ("F&S") can be summarized as follows (our terminology):

> While it would be ideal to have the input price index correspond to the total factor productivity (TFP) index, this "consistency" is not possible to maintain if one wants an input price index that is focused on BDS services rather than the broader telecommunications/broadcasting sector. Therefore, F&S propose to combine an input price index taken from the Connect America Cost Model (CACM), with some modifications, together with the official BLS productivity index based on KLEMS. Consistency between the input price index and TFP index is a "mathematical property" that, though desirable, is worth giving up in the interest of having a more narrowly focused input price index.

This view is fundamentally flawed. The mathematical property of consistency is not just an academically appealing feature that can be jettisoned when convenient. It goes to the heart of how TFP is constructed: the estimates of TFP that one obtains *depend crucially* on the index of input prices used. If one relies on a different index, then one gets different estimates of TFP. There is absolutely no reason to believe that changing the input price index would only have a small effect on TFP estimates. Indeed if the CACM-based index is likely to be different enough from the KLEMS index to make it more informative of actual cost conditions, then the presumption should be that the TFP estimates that would be obtained if TFP could be computed on the basis of the CACM index would be substantially different from the KLEMS TFP estimates on which Frentrup and Sappington still rely. As we will show in this declaration, we can say something much stronger: *If one*

[6] Christensen Supplemental Declaration.

uses a different input price index than the one used in the construction of the BLS KLEMS-based productivity index, and one properly adjusts the TFP index to maintain consistency between the input price and productivity indexes, there is no change to the X-factor.

To understand the close link between TFP estimates and the input price index, we begin with the observation that TFP growth equals the growth in the quantity of outputs minus the growth in the quantity of inputs.

Equation 1: Growth in TFP = Growth in Output Quantity – Growth in Input Quantity

However, in practice, one does not observe the quantity of outputs and inputs directly, in part because there is not just a single element in each category. Both outputs and inputs are heterogeneous and what one typically observes is the total revenues from the sale of different categories of outputs (e.g. wireline, wireless, TDM etc.) and the total expenditures on different categories of inputs (i.e., KLEMS). In order to construct TFP, one needs to move from observed expenditures on inputs, and revenues from outputs, to the corresponding quantities. It is this step at which the input and output price indexes play a critical role.

Since revenues equal output quantity multiplied by the output price, the growth in revenues is given by the following equation:

Equation 2: Growth in revenues = Growth in output quantity + Growth in output prices

The same holds for the growth in expenditures on inputs:

Equation 3: Growth in input expenditures = Growth in input quantity + Growth in input prices

Once one constructs the indexes for input and output prices (there is an extensive literature in economics that develops appropriate methodologies for doing this), one can then "back out" the implied growth in the quantities of inputs and outputs from equations 2 and 3:

Equation 4. Growth in output quantity = Growth in revenues – Growth in output prices

Equation 5. Growth in input quantity = Growth in input expenditures – Growth in input prices

Substituting these into the expression for TFP growth, we obtain the measured growth in TFP:

Equation 6. Growth in TFP = (Growth in revenue – Growth in output prices)

– (Growth in input expenditures – Growth in input prices)

This makes clear that any constructed index of TFP growth depends indirectly on the indexes used for *output and input prices*.[7] In the next section we consider what happens if one were to use a different input price index – which we will refer to as the 'alternative input price growth' -- in the X-factor rather than the one used to construct the underlying TFP index.

[7] The only exception to this are those theoretical cases, never observed in practice, where there is only a single output and a single input and we have direct measures of the quantity of both. This is obviously clearly not the case in telecommunications, or any other sector for that matter.

3. IF TFP COMPUTATIONS ARE ADJUSTED TO BE COMPATIBLE WITH THE NEW INPUT PRICE INDEX, THE X-FACTOR DOES NOT CHANGE

From the analysis presented above, it should be clear that, if *one were to use a different input price index than the one corresponding to the KLEMS productivity index, then one needs also needs to make a corresponding adjustment to the KLEMS-based TFP index*. We will show that, when done properly, these *two adjustments* will necessarily yield the same X-factor as before. It is only because F&S *fail* to make this necessary adjustment to the TFP index that he obtains an apparently higher X-factor. Meitzen and Schoech develop this same criticism in their review of the F&S report.[8]

To illustrate this point, we use the indirect formulation of the X-factor (this is equivalent to the FCC formulation under conditions discussed in our original report). The correct X-factor is as follows:

Equation 7. *X-Factor = (Growth in sector TFP- Growth in economy-wide TFP)*

– (Growth in sector input prices – Growth in economy-wide input prices)

But the X-factor we get when we use the alternative input price growth measure is given by the following equation:

Equation 8. *Alternative X-Factor = (Growth in sector TFP- Growth in economy-wide TFP)*

- (Alternative input price growth –Growth in economy-wide input prices)

Using equations 7 and 8, we obtain the following relationship between the Alternative X-factor and the correct X-factor:

Equation 9. *Alternative X-factor = X-factor - (Alternative input price growth*

– Growth in sector input prices)

As is clear from equation 9, if the alternative measure of input price growth is smaller than the one used in the construction of TFP, **and** no correction to the TFP index is made, the resulting X-factor will appear to be larger than it is in fact. This is exactly what F&S conclude. But this is simply a consequence of the fact that they do not adjust the TFP growth, as is required to preserve consistency.

The correct procedure would be for F&S to construct an "Alternative TFP growth" that is consistent with their Alternative input price index. This would be computed as follows:

Equation 10. *Alternative growth in sector TFP = (Growth in revenue*

– Growth in output prices) – (Growth in input expenditures

– Alternative input price growth)

Substituting equation 10 into equation 8, we get the correctly computed X-factor that corresponds to the alternative input price index (i.e., the X-factor that ensures consistency between the construction of the TFP index and the input price index). This yields:

Equation 11. *Correct Alternative X-factor = X-factor*

[8] Meitzen and Schoech, Supplemental Declaration (22 September 2016), pp. 3-4.

In other words, when the TFP is re-constructed correctly using the alternative input price index, the implied X-factor is the same as before. In effect then, the Frentrup-Sappington declaration is pointless. It only looks like it brings another perspective to the determination of X-factor because it is logically inconsistent.

We emphasize that the fact that one could not in practice easily adjust the TFP estimate to make it compatible with the new proposed factor price index is not a valid defense. If one knows that doing things right would produce no changes, it would seem strange to promote an analysis which does not produce the correct result on the grounds that only one half of the analysis can be done in practice.

4. WITH A NARROWER INPUT PRICE INDEX, ADJUSTING FOR DECLINES IN PRODUCTIVITY DUE TO THE INTERACTION BETWEEN SCALE ECONOMIES AND SHRINKING DEMAND IS EVEN MORE ESSENTIAL

We have explained why it is methodologically inconsistent to adopt a (putatively) more BDS-specific input price index unless one also makes the corresponding adjustment to the KLEMS-based TFP index, and that when one does this correctly, the resulting X-factor would be unchanged. But there is an additional point to emphasize. If one were to adopt a more BDS-specific input price index, it would be essential also to incorporate the adjustment to the TFP index to reflect the impact of economies of scale and the secular decline in BDS growth, as discussed at length in our original report. Of course, as we argued in our initial report, the Commission should incorporate such an adjustment even if it rejects the BDS-specific input price index proposed by F&S (as we recommend) and instead relies upon the official U.S. Bureau of Labor Statistics, KLEMS-based input price and TFP measures. But it is particularly important to make the adjustment for economies of scale and the decline in BDS growth – to make the TFP measure more focused on BDS rather than the sector as a whole -- if one were to adopt a BDS-specific input price index. In this reply declaration, we briefly summarize the justification for, and likely magnitude of, this adjustment (see Section 4.3.4. in our original report for more extensive discussion).

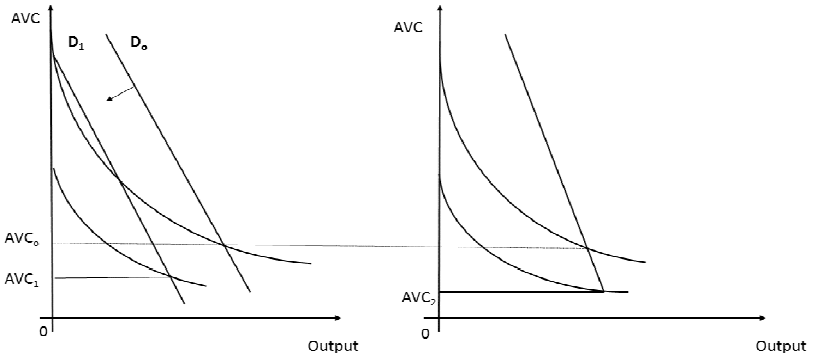
Changes in TFP at the communications/broadcasting sectoral level capture the evolution of costs for a range of products, not just DS1 and DS3. In the presence of economies of scale, a secular decline in demand – as has occurred for DS1 and DS3 – leads to higher costs. Since these TDM services account for a much larger share of the revenue base of ILECs than for the sector as a whole, TFP growth at the sector level *overestimates the actual productivity gains (cost declines) experienced by ILECs.* This conclusion holds even if the demand for TDM services increased for some period, as long as these legacy services grew at a slower rate than the aggregate of all other services provided by the sector.

The supply of DS1 and DS3 services involves significant fixed costs so that, for any given company, average costs are decreasing with the level of output. This is especially likely to be true for ILECs since, at the current stage of the life-cycle of these services, basic network investments have been made, though significant maintenance costs for this network remain. Over the recent past, ILECs supplying DS1 and DS3 services have faced intensified competition from CLECs offering identical services or close substitutes, such as Ethernet-based services, leading to significant erosion of their market shares and, in

fact, reductions in their actual levels of output. In economic terms, we can think of ILECs as facing a residual demand function (netting out competitors' output) that shifts to the left over time, moving the ILEC "up its average cost curve."

This is illustrated in the graph below where (for simplicity) we assume that DS1 and DS3 services experience the same downward shift in the average cost curve as the rest of the telecom industry (reflecting the effects of technological change), but the DS1/DS3-supplying ILECs also face a residual demand that shifts to the left due to competition from new, superior technologies. We see that the resulting decrease in average costs is higher for the rest of the sector (right-hand graph) than for the company operating in a subsector where it faces decreasing demand for its product. Since the change in TFP for the sector will be a weighted average of the changes in the subsector and the change in the rest of the sector, it will overestimate the cost reduction experienced by the regulated firm. This overestimation will be more acute when the sectors or firms experiencing decreasing demand account for a smaller share of the total sector.

Figure 1: The Effect of Shrinking Residual Demand



In our original report, we showed that one can estimate the effect of economies of scale on the discrepancy between true TFP growth for the ILECs and sector-wide TFP growth (such as the BLS index based on the KLEMS data). In particular, we show that the discrepancy can be expressed in the following simple formula:

$$DISCREPANCY \equiv TFP^S - dTFP^I = (1-\varphi)(r_1^S - r_1^I) * [dY_1 - dY_2]$$

In this equation, φ refers to the elasticity of total costs with respect to a proportional increase in both outputs (which is less than one if there are economies of scale), $r_1^S - r_1^I$ is the difference in the share of revenue that TDM services account for the sector as a whole and the ILECs, and $dY_1 - dY_2$ is the difference between the rate of growth in demand for TDM services versus other services. Using data from CenturyLink and estimates of economies of scale from the economic literature on telecommunications, we showed (see Table 4 in our original report) that sector-level measures of TFP growth overstate the true measure for the ILEC. Over the 2011-2015 period, the regulated price obtained from an X-factor computed on the basis of sector-wide KLEMS data would lead to a reset that is too stringent by between 0.36% and 0.81%. The same point will apply in setting the appropriate X-factor going forward, since the sharp decline in the demand for TDM services is expected to continue, as Ethernet and other new technologies substitute for the older technology.

Again, we emphasize that, even if the Commission rejects the use of the CACM-based approach proposed by F&S (as it should), the Commission should still make the BDS-specific adjustment to the X-factor to account for the effect of economies of scale and the secular erosion of demand for these legacy services, as summarized above and discussed in more detail in our initial report.

5. SUMMARY OF OTHER POINTS OF AGREEMENT WITH THE CHRISTENSEN SUPPLEMENTAL DECLARATION

Even if one where to ignore any issue of consistency between TFP estimates and the input price index and neglect the role of economies of scale, it remains that *the CACM is not an appropriate basis to build an input price index designed to capture the actual evolution of BDS services production over time*. There are two main reasons for this point, which on its own invalidates the F&S approach. First, reflecting its investment-oriented perspective, CACM considers the cost of building and operating a *new, green-field* network, not on the actual growth, maintenance and operation of the existing network. The optimal combination of inputs involved is unlikely to be similar for each of these two very different settings. Accordingly, the weight assigned to the price of each input in a CACM-based input price index are unlikely to be appropriate to assess the relevant cost of continued operation. Moreover, the input prices (at a single point of time) are measured for ten input categories that are themselves aggregates of many more sub-components of inputs.[9] There is no indication how these sub-components were aggregated, in particular whether state-of-the-art cost weighting methodology was used. Without this, the measurement error in these input prices, and the cost weights that are then constructed for each category, is likely to be substantial.

Second, to be useful in determining both the initial rate of reset of the price for BDS services and the X-factor to be applied to future regulation, a price index must accurately reflect the evolution of input prices over time. However, the CACM gives us a purely "one shot" picture of costs at a particular point in time. It provides absolutely *no guidance* as to how input prices have evolved or are likely to evolve over time. Instead, the "time dimension" of the input price index – which is the crucial element -- relies completely on a "low" and "high" scenario for price changes put forward by Commission. Specifically, the input prices growth series were derived from an FCC staff response to a critical 2013 peer review of the CACM. In response, the FCC staff assumed two alternative cost scenarios for the ten aggregated cost categories associated with CACM. These are at best just rough, aggregated guesstimates, as Meitzen and Schoech explain in greater detail in their Supplemental Declaration (pages 8 to 11). In short, the reliability of such "forecasts" is highly questionable, and uncorroborated by any hard evidence.

In developing their input price index from the CACM, Frentrup and Sappington also make a number of questionable, and potentially significant, assumptions. For example, the total cost of labor that they use is based on the U.S. Quarterly Census of Employment and Wages. This data source covers only salary compensation, but excludes the important, and growing, component of non-wage compensation – including fringe benefits, health coverage, and pensions. Given the importance of labor expenditures in total cost, this can easily lead to serious bias when estimating the overall growth in input prices. For

[9] These aggregated input categories include fiber, poles, conduit, drop, ONT, fiber pedestals, splitters, electronics, labor, and land and buildings.

example, assume that labor accounts for 70% of overall costs and that non-wage costs are equal to 40% of wage costs. Suppose for simplicity that the wage does not change from one period to the next, but the non-wage costs increase by 2.5% (this corresponds roughly to actual outcomes in the U.S. economy over the last ten years). Ignoring non-wage costs, as Frentrup and Sappington do, one would conclude that labor costs have not changed at all. However, in this illustration, the actual (fully-loaded) cost of labour has increased by 1% so that the overall input prices have grown by 0.7%. Ignoring this one required adjustment would lead to an X-factor which is too high by 0.7%.

Another drawback of the F&S adjustments involves how they construct the cost of capital measure. The original CACM measure is particularly inadequate, as it is simply the price of new investment goods. This is only one piece of the economically relevant cost of capital, as is well-established in the academic literature on capital investment and productivity measurement – which is the basis for official productivity measurement in the U.S. and Europe. In response to earlier criticism by Christensen Associates, F&S try to improve on the earlier proxy by introducing a measure of 'depreciation' and interest cost. But their approach fails to capture the actual economic lives of capital goods (which is related to the correct concept of 'economic depreciation'), or even actual physical depreciation rates. They instead are essentially based on projections of the time until replacement of the plant and equipment capital. Moreover, F&S make no adjustment in the construction of the cost of capital for changes in the value of investment goods. For capital goods whose prices are declining (as we often observed for new technologies in this, and other, sectors), this omission leads to an underestimate of the true cost of capital (as the resale value of the old capital is lower and thus the value depreciation is higher). This means that the input price change for this important input will be incorrectly computed, and this can lead to a significant error given that capital accounts (using the CACM cost weights) for nearly 40% of total costs.

These criticisms of the CACM-based input price index, among others, are made in more detail in the Christensen Supplemental Declaration (page 8 and below). Therefore we will not outline them in detail here, but we want to state clearly that we fully concur with the substance of those criticisms. From our perspective, these various failings of the CACM-based methodology mean that, even if the corresponding input price index were used on its own, with no connection to any measure of TFP, the fundamental discrepancy between the investment perspective of the CACM, and the number of assumptions and shortcuts on which the index relies, make it is little better than guesswork when it comes to tracking the actual costs of BDS services providers over time. Certainly, there is no reason to believe that the CACM-related input proportions and the prices relied on by Sprint provide a better match to a BDS input price index than the KLEMS-based input price index that corresponds to the official TFP measures constructed by the U.S. Bureau of Labor Statistics.

6. COMBINING BROADCASTING WITH TELECOMMUNICATIONS IN BLS KLEMS-BASED PRODUCTIVITY INDEX DOES NOT INTRODUCE SIGNIFICANT BIAS

In our initial report, and as we reiterate in this supplemental declaration, we strongly recommend adopting the official Bureau of Labor Statistics indexes of input price and TFP growth, which are based on the KLEMS data and state-of-the-art methodology. The main

concern that has been raised is that the KLEMS sectoral data include both telecommunications and broadcasting (SIC codes 515 + 517). If TFP grew faster in telecommunications (and DS1/DS3 services specifically) than in broadcasting over the last decade (the time span for computing the X-factor that we recommend in our earlier report), the KLEMS sectoral estimate would overstate the true TFP growth in telecommunications. On the other hand, if TFP grew faster in broadcasting, then the KLEMS estimate would be an overestimate, not an underestimate.

It is worth noting that broadcasting accounts for only about a quarter of the overall BLS telecommunications and broadcasting" sector.[10] So even if there is a divergence between TFP growth between the two sub-sectors, the 'bias' should be limited. But the critical point is that it is not clear at the outset which way the bias would run. Broadcasting has benefitted from the tremendous growth in wireless telecommunication innovation too, so it is not at all obvious that TFP growth in broadcasting has been lower than "wireline telecommunications," which is the most relevant comparator in the available data for purposes of price cap regulation of BDS services. While there is no direct evidence on this question because there are no separate TFP indexes for the two sub-sectors, we will provide some illuminating evidence on this question below using data on the growth in labor productivity (output per hour), rather than TFP.

In the table below we present the average annual rate of growth in labor productivity over the period 2005-14 for the sub-sectors in the telecommunications and broadcasting sector.[11] This is the period which we argued in our original report is the most appropriate for computing the X-factor for the reset and the price cap going forward.

Table 1: Average Annual Growth in Labor Productivity, 2005-14

Broadcasting (SIC 515)	6.6 %
Wired Telecommunication Carriers (SIC 5171)	0.6 %
Wireless Telecommunications Carriers (SIC 5172)	14.4 %

It is not surprising that wireless carriers exhibit much higher labor productivity growth than the other sub-sectors. However, what is striking is that the productivity growth is also much faster over this relevant period in broadcasting as compared to that for wired carriers, and it is the latter which is the relevant sub-sector since price cap regulation targets TDM-based services. This evidence contradicts the presumption expressed by Sappington and Zarakas in their original report, which was that the inclusion of broadcasting would lead to an underestimate of the relevant productivity growth.

[10] Based on 2014 employment data from the BLS, broadcasting (SIC code 515) accounted for 27.5% of the total combined sector. Wired telecommunication carriers (SIC code 5171) accounted for 58.2%, and wireless carriers (SIC code 5172) accounted for the remaining 14.3%.

[11] We compute the average rate of growth in labor productivity for the period 2005-14 using data from the Bureau of Labor Statistics. See BLS, *Productivity and Costs by Industry: Selected Service-Providing and Mining Industries, 2005,* www.bls.gov/news.release/archives/prin_06082007.pdf; and Productivity and Costs by Industry: Selected Service-Providing Industries, 2015, www.bls.gov/news.release/archives/prin_15182016.pdf.

Of course, this is based on a comparison of labor productivity growth rather than TFP growth. What one would like to know is the ranking of these sub-sectors in terms of their TFP growth. The question is: Could the ranking based on labor productivity, shown in the table above, be reversed if one made the comparison using TFP? Of course, this cannot be directly checked since KLEMS-based TFP measures are not available at the sub-sectoral level. To address this question indirectly, we begin by noting that the growth in labor productivity is driven by two factors: growth in TFP (which captures the effects of technological change and economies of scale, as explained in our original report) and the growth in other inputs relative to labor input. If other inputs, the most important being capital, grow faster than labor input, this increases labor productivity, even in the absence of technological change or economies of scale. The only way that the ranking of sub-sectors by labor productivity, presented in the table above, could be reversed by using TFP is if the growth of other inputs (relative to labor) is much faster for wireless carriers and broadcasting than it is for wired carriers. This is unlikely to be the case. Indeed, we can show technically that the magnitude of this difference that would be required to reverse the ranking of sub-sectors (based on TFP) is implausibly large.

To illustrate this, suppose the only inputs are labor and capital (they account for the bulk of input expenditures). The growth in labor productivity equals the growth in TFP plus the cost share of capital multiplied by the growth in capital relative to labor. Symbolically, $q - l = tfp + s(k - l)$ where *tfp* is the growth in TFP, and *q, l* and *k* denote the growth rates of output, labor and capital, and *s* denotes the share of costs accounted for by capital. A typical value for this share, *s,* is 0.4 (this is the value in the CACM cost data). From Table 1 in the text, the value of $q - l$ is 6.6% for broadcasting and 0.6% for wired telecommunications carriers. Thus the difference between the growth in labor productivity in broadcasting ('B') and wired telecommunications ('W') -- which is given by the expression $(q\text{-}l)^B - (q\text{-}l)^W$ -- is equal to 6.0%. Using the equation above and the value *s=0.4*, the only way for the growth in TFP to be higher for wired carriers would be if $k - l$ for broadcasting was *15 percentage points* higher than for wired carriers (computed as 6.0/0.4). This is utterly implausible. This implies that the observed ranking of these two sub-sectors on the basis of labor productivity will also hold if one used TFP. In short, we can reasonably infer that TFP growth over the last decade was higher in broadcasting and wireless telecommunications than for wireline carriers.

The conclusion from this analysis is that there is *no evidence* that the KLEMS-based measures of TFP growth, constructed by the BLS, understate the TFP growth over the last decade for wired telecommunications, and this is even more emphatic for TFP related to DS1 and DS3 which are the focus of the price cap regulation. If anything, quite the opposite. Therefore, there is no basis for rejecting the KLEMS-based measure, despite the fact that it aggregates broadcasting and (wired and wireless) telecommunications.

7. CONCLUSION

The first Sappington declaration embraced KLEMS data as the basis for computing X factors which could be used both to determine the initial "reset" of BDS service prices and to control these prices in the future. Unfortunately, the rest of the analysis was marred by errors (the failure to correct for the fact that value added represents only a fraction of output) and inconsistencies (using a price index that did not include the prices of factors accounting for most of value-added). This new declaration does not make any reference to this earlier analysis. Surprisingly, given his earlier reliance on EU-KLEMS data,

Sappington now champions an input price index relying on the CACM -- i.e. on a static, highly stylized model of a green-field network for fiber-to-residence (not the actual BDS network in place). Not only that, but the critical components of this input price index – the projected prices for the various input categories -- are not based on hard evidence, but are drawn instead from hypothetical projections by Commission staff. This change of heart is not explained.

Just like the first declaration submitted by Sappington and Zarakas, the new approach they propose suffers from logical inconsistencies. In particular, it makes no analytical sense to use a price index which is sensibly different from the index that was used when deriving FTP estimates. While Frentrup and Sappington attempt to present such consistency as simply a nice "mathematical" property cherished by academics but of little empirical significance, it is nothing of the sort. Divorcing the construction of the TFP estimates from the input price index that was used to obtain them is methodologically wrong, and leads them to conclude that the X-factor is higher than is justified by the hard evidence. When done correctly, ensuring consistency between the input price and TFP indexes, there is no change in the X-factor at all.

The Fentrup-Sappington declaration is unreliable for two further reasons. The first is that, if one tries to find a factor price index which closely reflects the cost conditions of individual BDS service suppliers, then it becomes even more important to control for the change in these suppliers' costs due to reduction in demand that, because of scale economies, lead to increase in the firm's average cost of production. Despite the fact that this effect was explained thoroughly in our own first report, Frentrup and Sappington just ignore the whole issue.

The second major issue is that CACM models are not designed to provide a reliable measure of the evolution of actual costs over time – which is what is required to compute an accurate X-factor. The CACM is investment (stylized green-field network based, not corresponding to the existing, operational network and only provides a one-shot picture of cost conditions, at best. Moreover, the rules governing the allocation of fixed common costs are quite arbitrary. Because of this Frentrup and Sappington are forced to impose a number of completely ad hoc adjustments to the CACM data. These adjustments have no solid basis. Indeed, this is one of the reasons that our first report – as well as the Christensen August 9th Report – rejected any reliance on CACM data. And in their first declaration on behalf of Sprint, Zarakas and Sappington concurred in rejecting the CACM data. While any expert would of course want to have an input price index which closely reflects the cost conditions of BDS services, coming up with a price index which essentially relies on guesswork cannot possibly help. On top of that, the inconsistency between the input price index and TFP measure used to construct the X-factor fundamentally undermines their analysis, and with it their claim that the X-factor should be increased.

For all of these reasons, we conclude that the new Frentrup-Sappington declaration is no more reliable than the initial report submitted by Sappington and Zarakas, which the authors themselves have now chosen to jettison entirely.